Providing a Safe Water Supply in the African Bush

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PROVIDING a safe water supply for a team of epidemiologic investigators in the African bush in the Republic of Chad was the task of the sanitary engineer member of the geographic epidemiology unit of the Johns Hopkins University. Nine investigators from the United States, two Chadian male nurses, and two native cooks were in the field for 3½ months, February through May 1967, while carrying out health surveys in four villages located in different areas of the country (fig. 1).

The water prepared by the engineer was used by camp personnel for drinking, cooking, dishwashing, bathing, handwashing, and various uses in the laboratory and medical examination tents. The laundry was done outside the camp at each site by a villager contracted for this purpose. Camp aides, hired from the villages at each survey site for various tasks, used the prepared water only for consumption during the hours they were in the camps. During the entire period, the average consumption of prepared water by the permanent group was 11 gallons per person per day. The water supply was required to be free of pathogenic bacteria, viruses, protozoa, and the cercariae of schistosomes.

Adequate treatment of water to meet the requirements of the camp could not be accomplished efficiently or readily by boiling or by the simple addition of halogen tablets. The relatively large amount of water required, the high turbidity of raw waters, the shortage of fuel, the necessity for reliably safe water, and the need for efficient use of time and materials necessitated adoption of a more sophisticated technique.

We reasoned that adequate treatment can be attained with prechlorination, coagulation, sedimentation, postchlorination as necessary, and adjustment of pH within 36-gallon Lyster bags. The process used is shown in figure 2. A survey by a pilot team in June 1966 indicated that many raw water sources had a high content of total solids; therefore coagulation and sedimentation were considered essential. Chlorine doses were to be adjusted to give a free chlorine residual of 2.0 mg. per liter following the treatment period. This level was arbitrarily selected to insure protection against pathogenic organisms commonly associated with water sources in primitive areas of the world.

The cercariae of *Schistosoma mansoni* and *Schistosoma haematobium* are readily inactivated by free chlorine residuals sufficient to kill enteric bacteria (*1*). However, free chlorine

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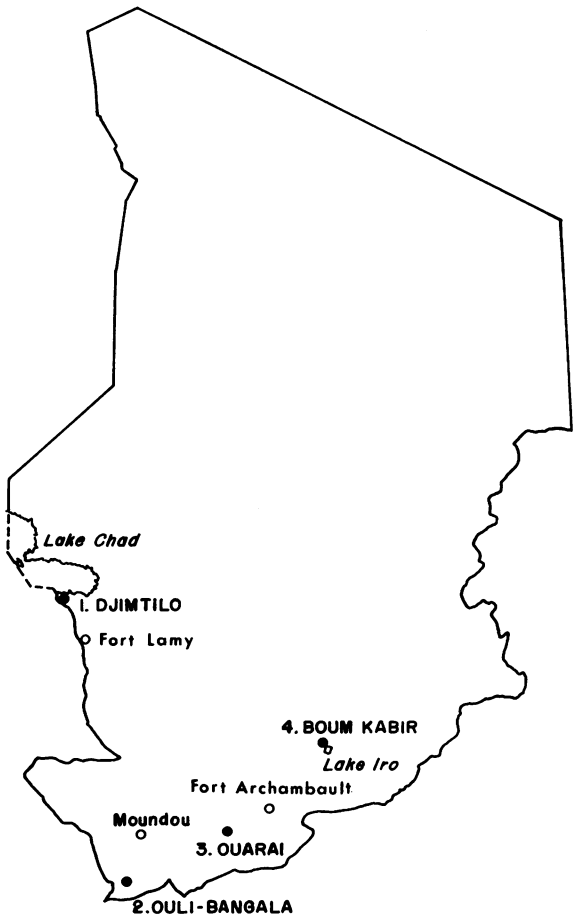
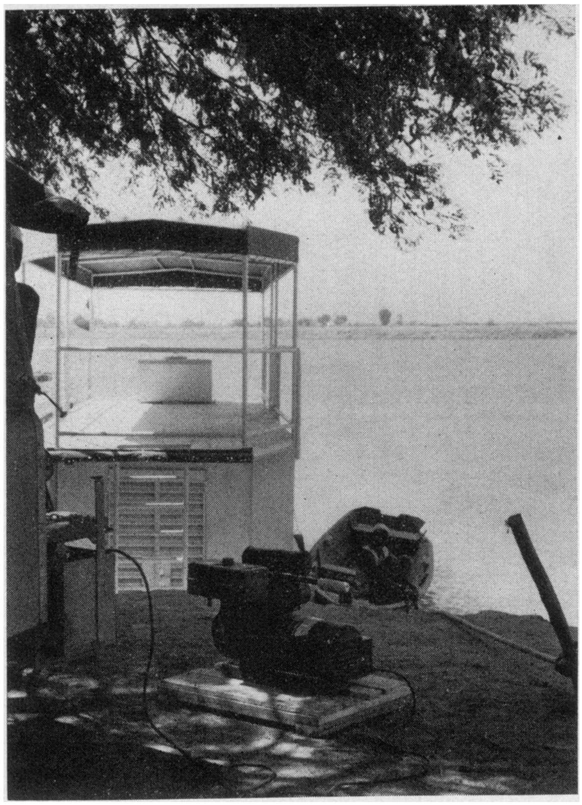
residuals of a greater magnitude are required for cysticidal and virucidal activities depending upon the temperature and pH (*2*). The use of iron salt as the coagulant is known to lower the pH of the water being treated and thus produces greater efficiency in disinfection. The free chlorine residual at 2.0 mg. per liter was considered necessary for the conditions to be encountered. At this level, protection against leptospirae would also be assured (*3*). The chlorine dose required to attain the level of residual will also kill the *Cyclops* which serve as the intermediate host of *Dracunculus medinensis* (*4*).

Equipment and Supplies

The selection of equipment and supplies was based on dependability, effectiveness under all conditions to be encountered, efficiency, ease of

Figure 1. Republic of Chad, principal cities and survey sites





A camp aide holds the submersible pump in the Chari River with a rope. The alternator is on the bank.

handling, and weight. The equipment and supplies were shipped to Chad by air freight and carried by truck from site to site. Initially, we thought it might be necessary to draw water not only from a lake and rivers but also from several fairly deep wells. For this purpose, we obtained a Gould $\frac{1}{4}$-hp. submersible pump and an alternator with a rated output of 2,460 watts. The alternator was also used occasionally to supply current for the laboratory tent. Tripods were designed and constructed in Fort-Lamy from 10-foot long, $1\frac{1}{4}$-inch galvanized iron pipes, and regulation 36-gallon U.S. Army Lyster bags were hung from them. Two 50-gallon steel drums with tops removed served as tanks and were carried on the bed of a pickup truck to transport water from distant sources to the camps.

The chemicals for treatment consisted of calcium hypochlorite (HTH), Ferri-floc supplied by the Tennessee Corporation, coagulant aid N-17 supplied by the Dow Chemical Company, and soda ash. For special needs, small quantities of sodium thiosulfate, sodium hexametaphosphate, and other chemicals were available. HTH was selected because of its high available chlorine content; however, this chemical had to be packed in special containers to meet the International Air Transport Association regulation for air freight. Ferri-floc was the coagulant of choice because of its effectiveness over a wide range of pH. The coagulant aid N-17 is nonionic.

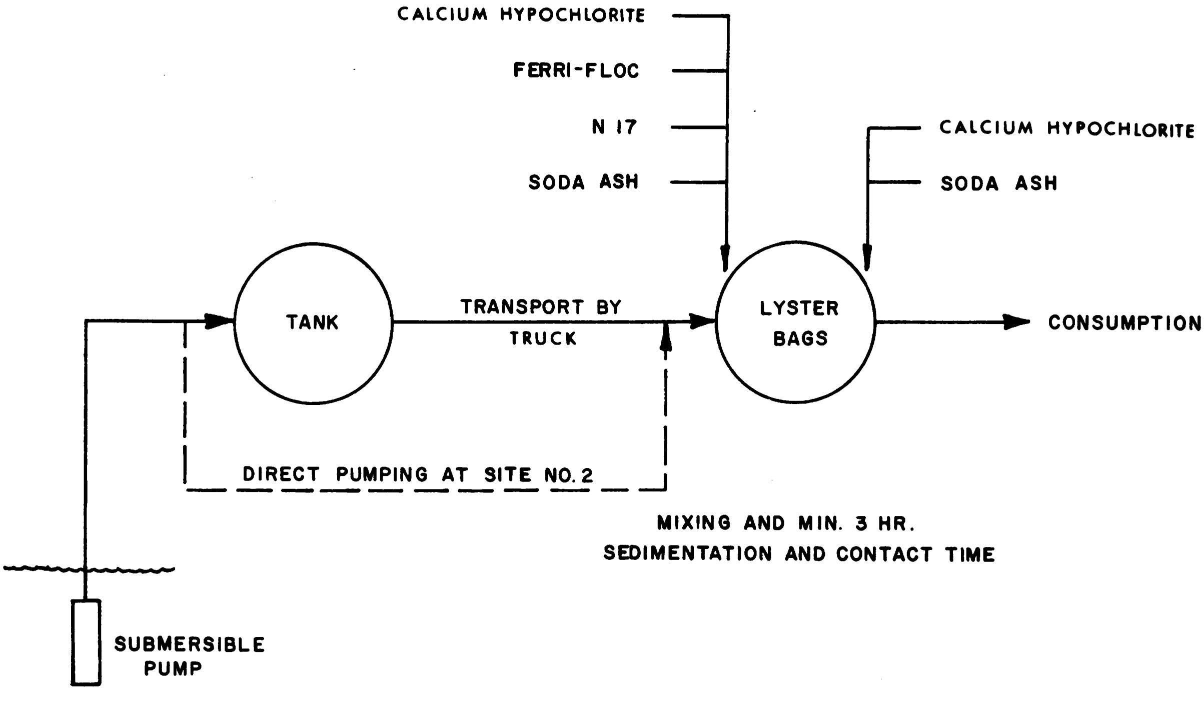
Field Operation

The information obtained during the pilot survey of water sources in the four study sites was based on visual observations and reports of local informants. This information was inadequate, however, and for one of the sites it was found to be inaccurate. The survey report had indicated that an adequate supply of water was available throughout the year from deep wells in study village No. 3. However, we found that the three wells in the village had yields barely sufficient to provide the normal requirements of the village population. Therefore, we were forced to use an alternate source—a creek approximately 3 kilometers away. At each site all possible sources within a reasonable distance were considered, and the source with the best quality and sufficient quantity was chosen. Subsequently, water sample examinations were conducted as part of the survey. The results of these examinations are shown in table 1.

The sanitary engineer was with the advance team whenever the camp was moved. Approximately 25 gallons of prepared water was carried by the team for immediate needs. Therefore it was necessary to locate and prepare water at the earliest possible time after arrival at each new campsite. The previously prepared water was conserved for drinking and cooking needs, and a temporary supply of water for washing was obtained from available sources nearby and chlorinated heavily. After this emergency measure, a more thorough investigation was made and the supply source was determined. Pumping equipment and accessories were loaded into the pickup truck by camp aides, and the routine for obtaining the water was established.

The submersible pump was easy to handle and useful whether lowered into a deep well or into a creek or a lake. When the pump was used in shallow waters, a handy wooden crate made for

Figure 2. Flow diagram of water treatment process used in the African bush



soft drink bottles was used to keep the pump off the bottom. The water was pumped from the source into the steel drums. The drums were then transported to the camp and the water was transferred into the Lyster bags.

When the bags were filled, HTH, Ferri-floc, and coagulant aid were added. An attempt was made to dose the water to a level that would give the desired free chlorine residual at the end of the 3-hour treatment period. The coagulant dose was determined by trial until a good floc formation was evident. The camp aides mixed the chemicals in the Lyster bags with boat paddles. A minimum of 3 hours' holding time was given for clarification, and then the residual chlorine was checked with a Hellige color comparator kit using the orthotolidine and arsenite reagents. When necessary, additional chlorine was added to bring the free chlorine residual up to 2.0 mg. per liter. (For the Chari River water, the free chlorine residual was maintained at 3.0 mg. per liter because the pH of the raw water was higher.) When adjustment was necessary, the holding time was extended by 30 minutes to several hours. When the chlorine residual was satisfactory, the pH was checked with the Hellige color comparator kit, using the wide-range indicator solution, and adjusted with sodium carbonate to slightly above 7.0. Reasonably accurate dosing was achieved by calculating the requirement based on a test using a beaker of raw water and adding stock solution of sodium carbonate with a dropper.

A total of nine Lyster bags were used so that the supply could be kept ahead of the demand and the fairly high loss rate due to evaporation. Strict control was kept on use of water from the bags by tagging them with red and yellow strips of cloth. Red indicated "hands off" and yellow indicated prepared water ready for use. The camp aides, with few exceptions, learned the system immediately.

Table 2. Range of chemical doses used in treatment of water

Chemical	Dose ranges (mg. per l.)
HTH as available chlorine	5.0–14.6
Coagulant aid N–17	1.0–21.6
Ferri-floc	30.0–333.0
Soda ash	1.0–63.0

The dose ranges used in the treatment of the water are shown in table 2. A fairly high dose of coagulant was required to "crack" the Lake Iro water, which was highly turbid due to colloidal clay. This caused the pH to drop sharply from 7.5 to a value close to 5.0. The requirements of HTH for disinfection and soda ash for pH adjustment were similarly high. The chemical requirements of waters at the other sites were considerably lower.

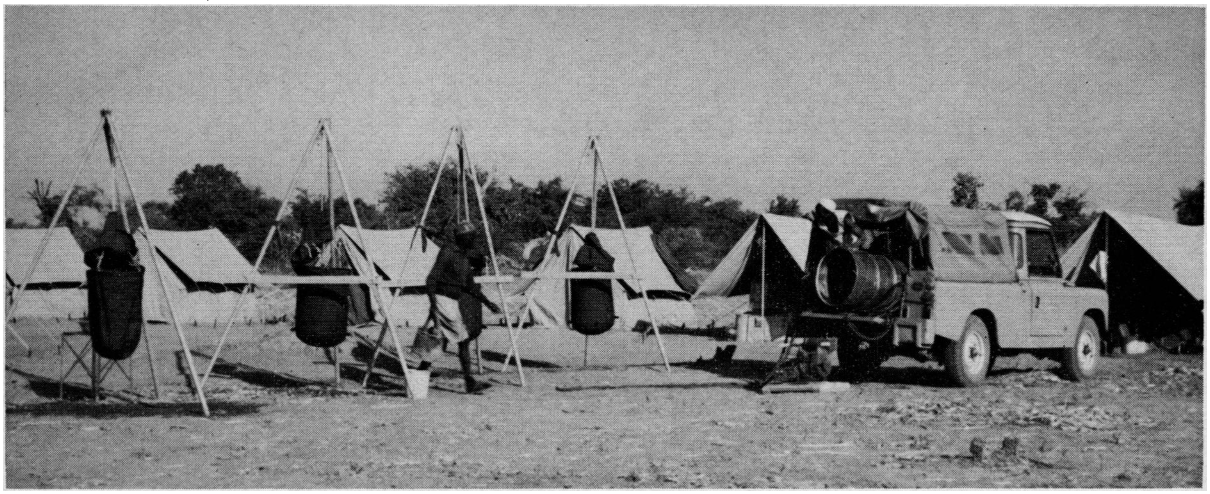
The treated water had no noticeable taste, other than a slight chlorine taste, or odor. Although sodium thiosulfate was available, it was used only to dechlorinate the water used for laboratory work.

Problems and Hazards

We were able to operate the equipment properly after we became familiar with its idiosyncrasies. However, handling the equipment when pumping raw water posed a problem, especially in relation to possible exposure to the cercariae of the schistosomes believed to be present. Wearing rubber gloves made handling the equipment more slippery, and it was impossible for the engineer and the camp aides to avoid some contact with the raw water.

Table 1. Results of examination of water samples

Site No. and source	Temperature (°C.)	Color (platinum-cobalt units)	Turbidity (Jackson turbidity units)	Coliforms (per 100 ml.)	pH
1. Chari River	25	67	----------	----------	8.3
2. Lim River	25	25	10	74	7.4
3. Petit Mandoul	27	13	8	2,590	7.2
4. Lake Iro	31	2,325	790	1,020	7.5



In a camp near the village of Djimtilo, Lyster bags are filled by camp aides with water brought in steel drums from the Chari River.

Although treatment of the water in the Lyster bags proved to be a very successful procedure, drawing water through the spigots presented another problem. When drawing more than a glassful of water the spring mechanism tired the hand, and before long members of the team and the camp aides were unscrewing the spigots when they wanted large amounts of water. Unscrewing the spigots caused the plastic threads to wear out and leaks to develop at the spigots.

A major problem was the failure of the ropes suspending the Lyster bags. Both manila and high-strength nylon ropes were used. While both failed through wear, the nylon rope was far the inferior of the two, often suddenly giving away. The loss of prepared water in the heat of the bush meant costly expenditure of time and effort.

A few changes have been suggested which may help to solve some of the problems encountered: the possible use of chains instead of ropes, a new design for the spigots, and the construction of lightweight tripods.

Adequacy of Process

While some changes will be made on future expeditions, the system employed, on the whole, was adequate and effective. When bacteriological tests of the prepared water were conducted on several occasions after neutralizing the chlorine with sodium thiosulfate and using the Millipore water analysis kit and M-Endo medium, the coliform counts were always found to be negative. During the entire period in the field the health of the personnel was good, and the water supply in the camps was not considered responsible for any cases of diarrhea among the team members.

Summary

An experience with treating water in the African bush in the Republic of Chad proved that potable water can be prepared in the Lyster bag by prechlorination, coagulation, sedimentation, postchlorination, and adjustment of pH.

The treated water had to be free of pathogenic bacteria, viruses, protozoa, cercariae of schistosomes, and *Cyclops* which serve as the intermediate host of *Dracunculus medinensis*. This result was attained by maintaining a free chlorine residual throughout a 3-hour treatment period. The free chlorine residual maintained in water drawn from the Chari River was 3 mg. per liter and at three other sites the level maintained was 2 mg. per liter. The bacteriological quality of the treated water was excellent.

A submersible pump and a portable alternator were found to be ideal equipment for the bush. They were relatively easy to handle and effective for drawing water under varying conditions. The system used was adequate, effective, and relatively uncomplicated, and it could be operated with the help of a few untrained villagers.

REFERENCES

(*1*) Chandler, A. C., and Read, C. P.: Introduction to parasitology. John Wiley & Sons, Inc., New York, 1962, p. 294.

(*2*) Sartwell, P. E.: Preventive medicine and public health. Ed. 9. Appleton-Century-Crofts, New York, 1965, p. 949.

(*3*) Chang, S. L., Buckingham, M., and Taylor, M. P.: Studies on *Leptospira icterohaemorrhagiae*. IV. Survival in water and sewage: Destruction in water by halogen compounds, synthetic detergents, and heat. J Infect Dis 82: 256–266, May–June 1948.

(*4*) Babbitt, H. E., and Doland, J. J.: Water supply engineering. McGraw-Hill, Inc., New York, 1955, p. 408.

Public Health Service Staff Appointments

Theodore D. Woolsey has been appointed director of the National Center for Health Statistics. The Center is the statistical arm of the Public Health Service and is responsible for the nationwide collection, analyses, and dissemination of vital and health statistics.

Mr. Woolsey, deputy director of the Center since 1963, succeeds Dr. Forrest E. Linder, who is teaching at the University of North Carolina School of Public Health.

After receiving a bachelor of arts degree from Yale University in 1936, Mr. Woolsey did graduate work at the Johns Hopkins School of Hygiene and Public Health. He entered the Bureau of the Census in 1938 and later spent 2 years as a statistician with the New York State Department of Health.

Returning to the Census Bureau early in World War II, Mr. Woolsey was in charge of a program to gather information rapidly on national mortality. From 1944 to 1946, he served as a naval lieutenant, working as a medical statistician in the Bureau of Medicine and Surgery.

In 1946 Mr. Woolsey became chief of the Special Surveys Section of the Division of Vital Statistics when the division was transferred from the Department of Commerce to the Public Health Service, and in 1947 he was appointed supervisory statistician of morbidity and health statistics in the Service's Division of Public Health Methods.

Mr. Woolsey was named assistant director of the newly created U.S. National Health Survey in 1956, and in 1960 he became its chief.

A member and former president of the Washington Statistical Society and a member of the Population Association of America, Mr. Woolsey is also a fellow of the American Statistical Association and the American Public Health Association.

Dr. Frank Wray McKee, former director of medical services for the Rochester (N.Y.) Regional Health and Hospital Council, has been appointed director of the Division of Physician Manpower.

Primary responsibilities of the Division of Physician Manpower are to evaluate the supply of physicians, assess the ways in which they are functioning, and encourage innovation in meeting the nation's needs for medical care.

In his recent work with the Rochester council, Dr. McKee was involved in the coordination of physicians' organizations and with the medical affairs of the 11-county hospital council. From this experience he gained a working knowledge of the complexities of physician manpower problems in a rural-urban area.

A graduate of Hamilton College in 1936 and of the University of Rochester School of Medicine and Dentistry in 1943, Dr. McKee was a research investigator in clinical pathology at the University of Rochester. From 1954–62 he was professor of pathology and director of clinical laboratories at the University of California at Los Angeles, where he organized and recruited the staff in the clinical laboratory when the hospital was opened in 1955. In 1962 Dr. McKee accepted the position of associate dean at the University of Rochester School of Medicine and Dentistry and served as acting dean during 1964–65.

In 1962 Dr. McKee was appointed to the Department of Defense Advisory Panel on Medical and Biological Sciences. He is a member of Phi Beta Kappa, Alpha Omega Alpha, and Sigma Xi.